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Jin et al.

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(54) **LOUDSPEAKER RESIN MOLDING COMPONENT AND LOUDSPEAKER USING THE SAME AND ELECTRONIC DEVICE AND MOBILE APPARATUS USING THE LOUDSPEAKER**

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H04R 9/02 (2006.01)
H04R 7/02 (2006.01)
G10K 13/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04R 7/02*** (2013.01); ***H04R 31/003*** (2013.01); ***H04R 9/025*** (2013.01); *H04R 2207/021* (2013.01); *H04R 2307/029* (2013.01)
USPC **381/426**; 381/428; 181/167; 181/169

(58) **Field of Classification Search**
USPC 381/412, 426–428, 398, 421, 396; 181/167–170; 162/141–149; 423/447.1–447.9; 264/328.1; 524/13
See application file for complete search history.

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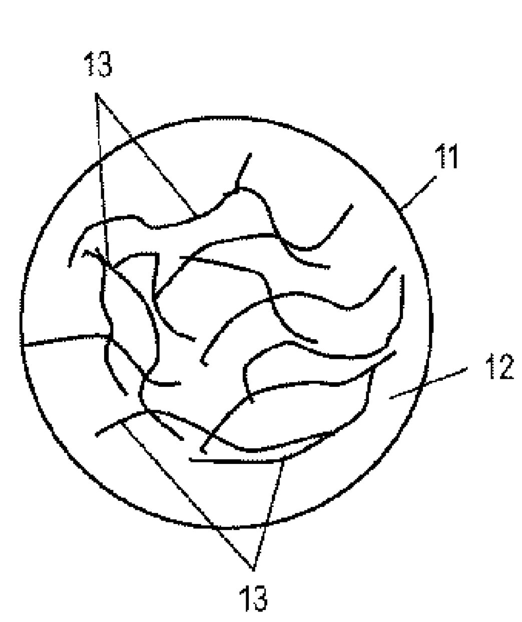
(57) **ABSTRACT**

A loudspeaker resin molding component includes resin and bamboo fibers refined to have a microfibril status and carbonized. By this configuration, such a loudspeaker resin molding component can achieve both of a high elastic modulus and a large internal loss.

19 Claims, 5 Drawing Sheets



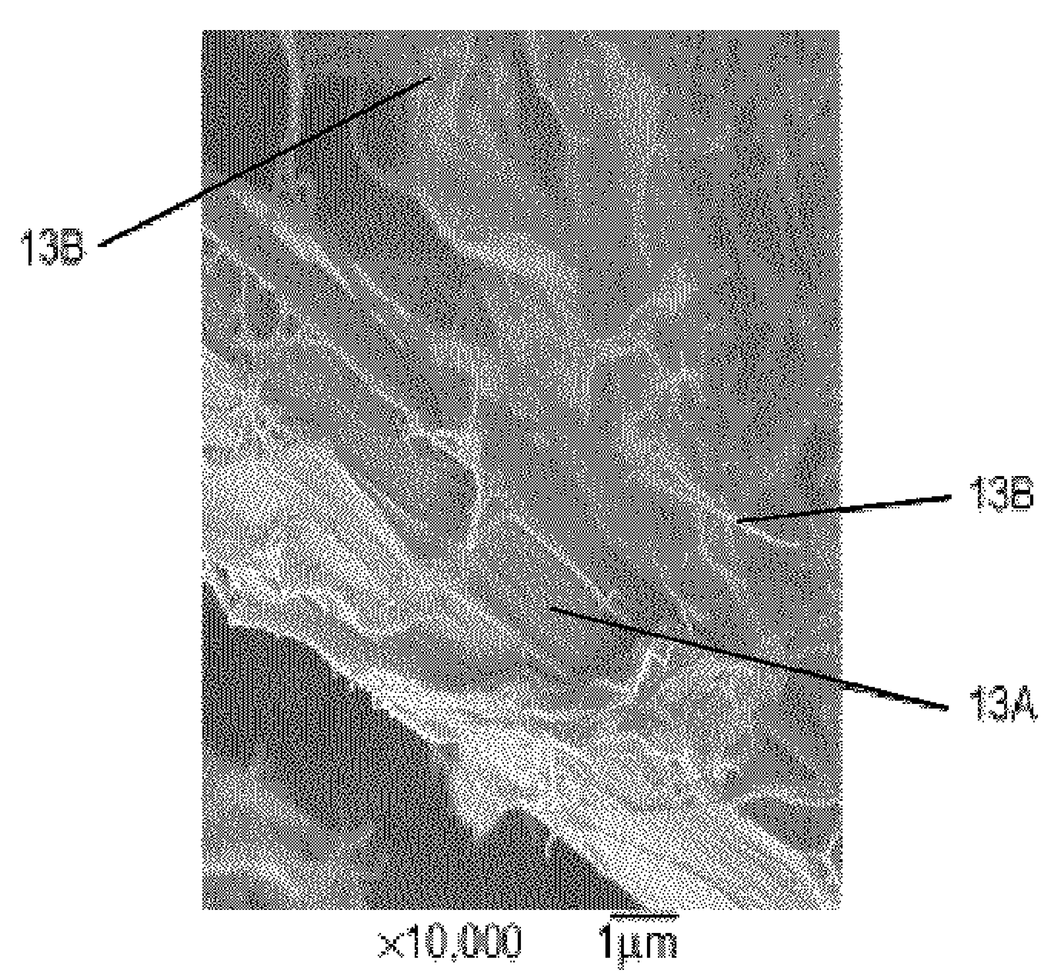


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FIG. 1

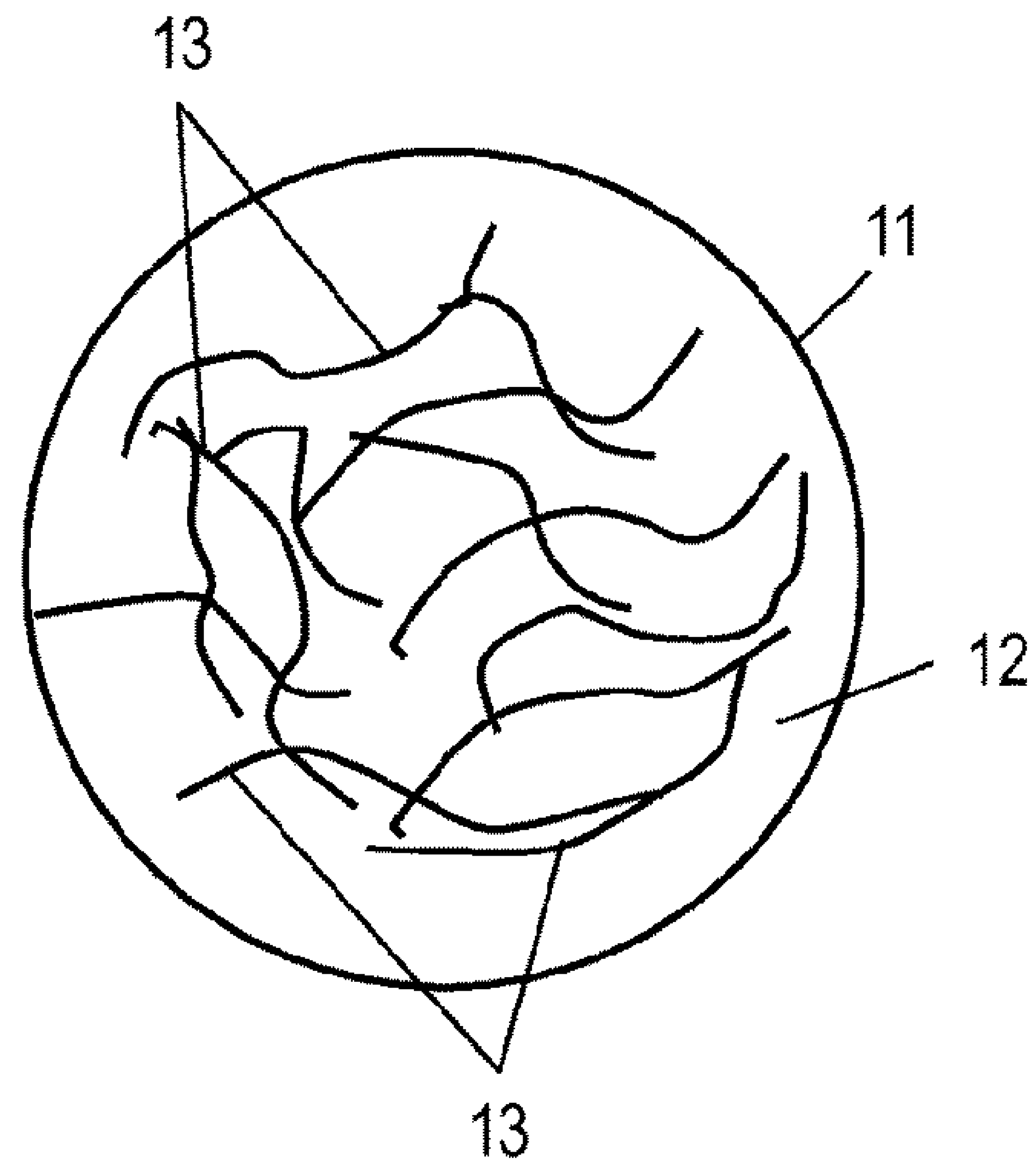


FIG. 2

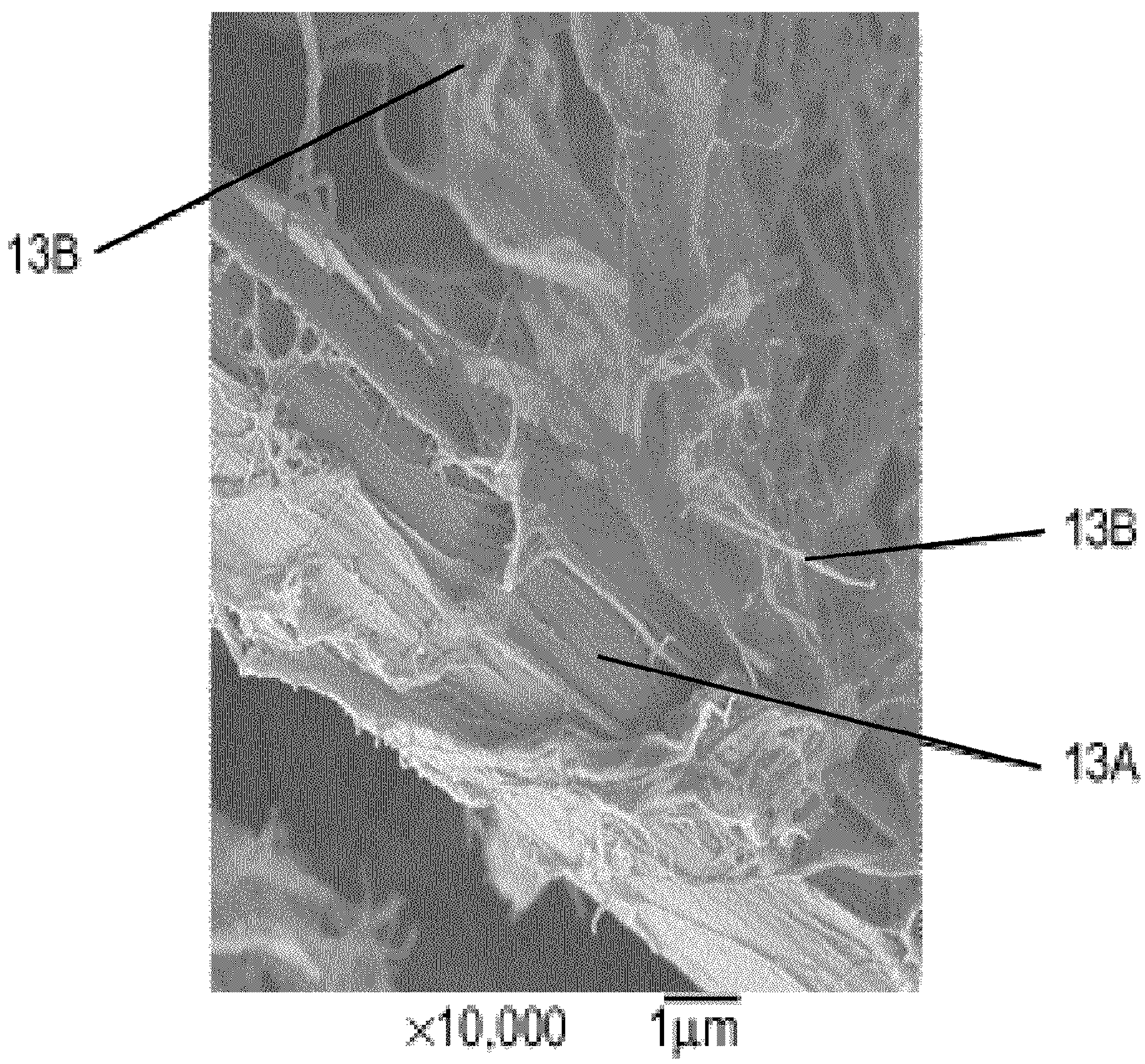


FIG. 3

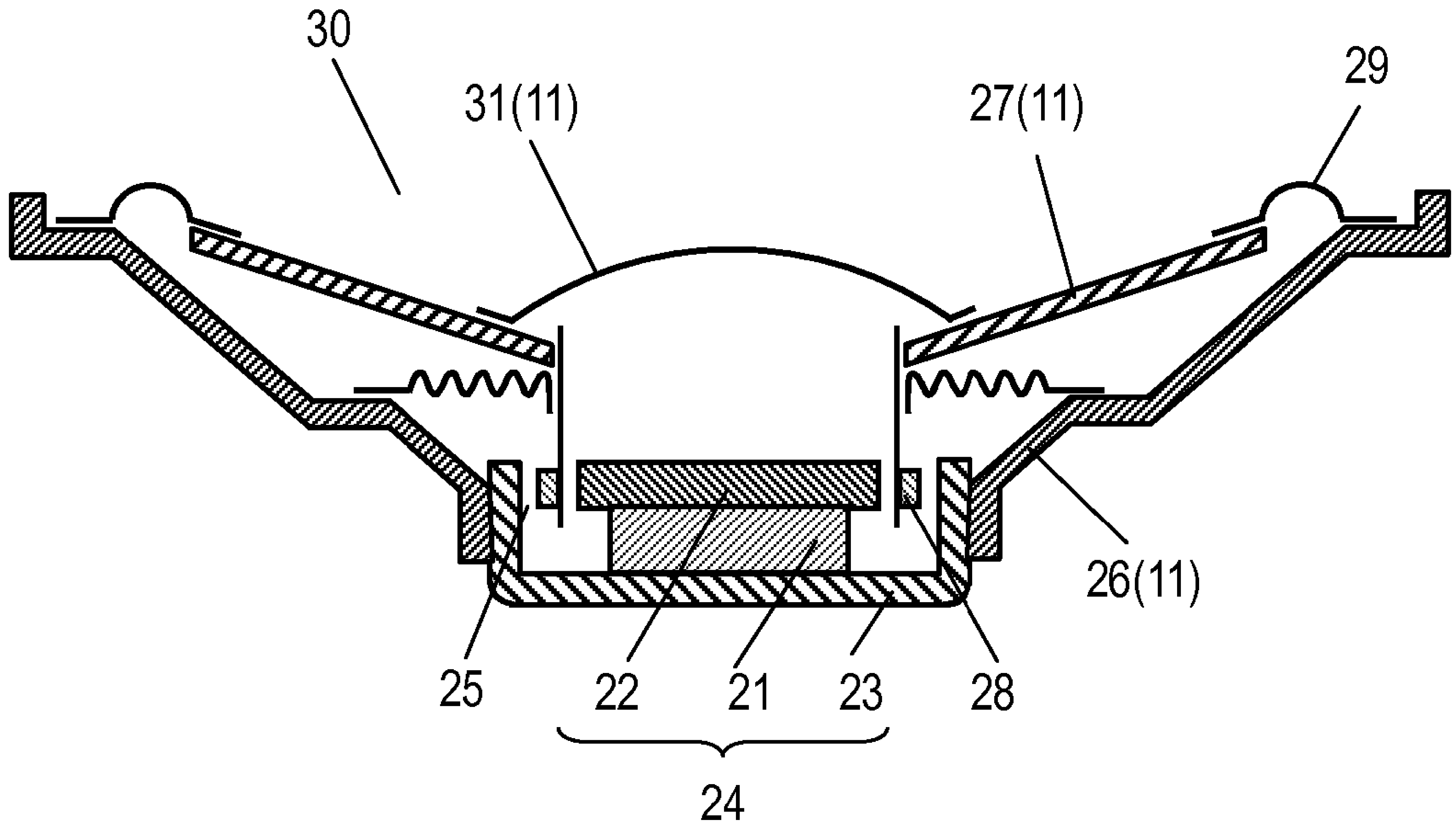


FIG. 4

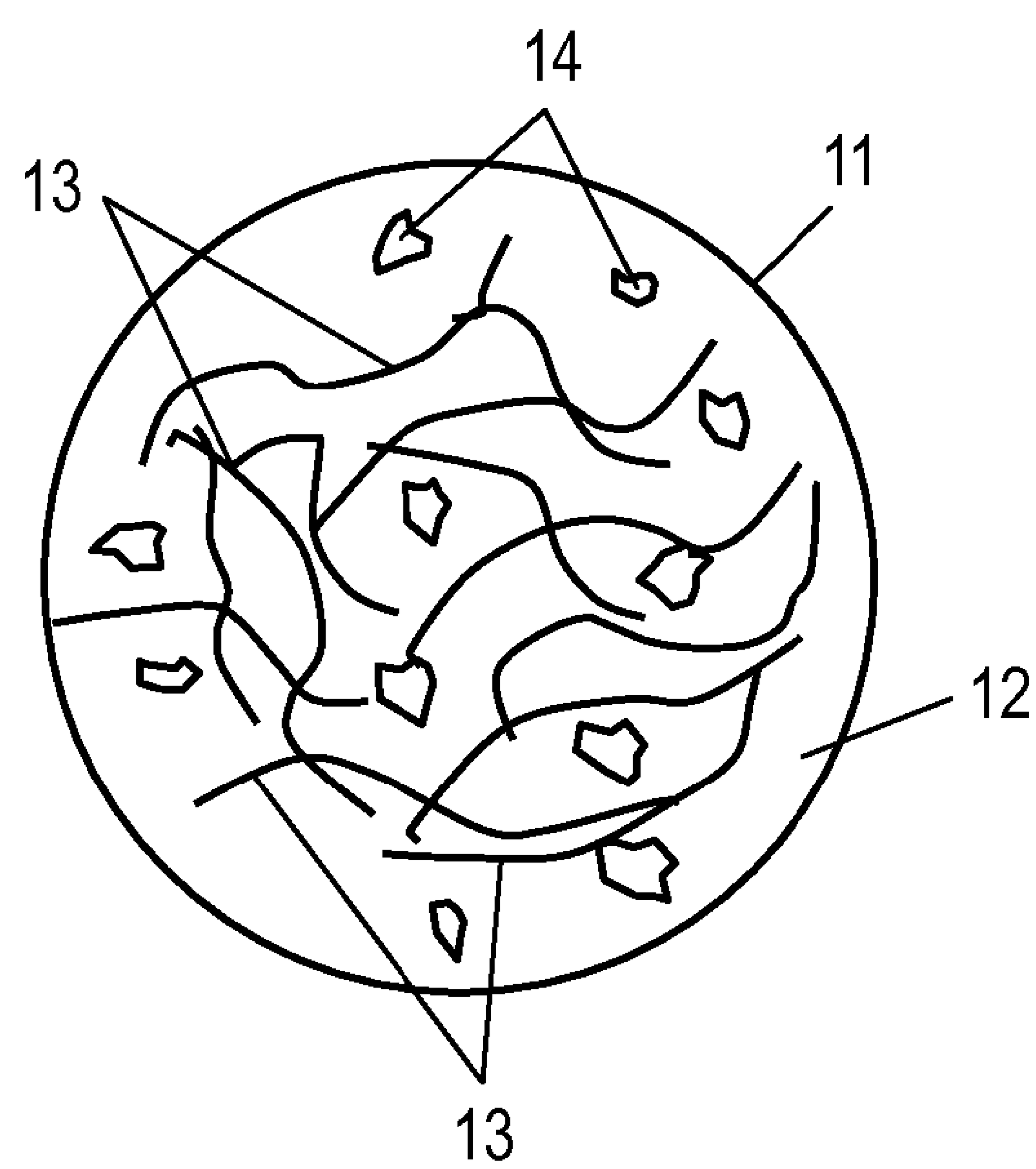


FIG. 5

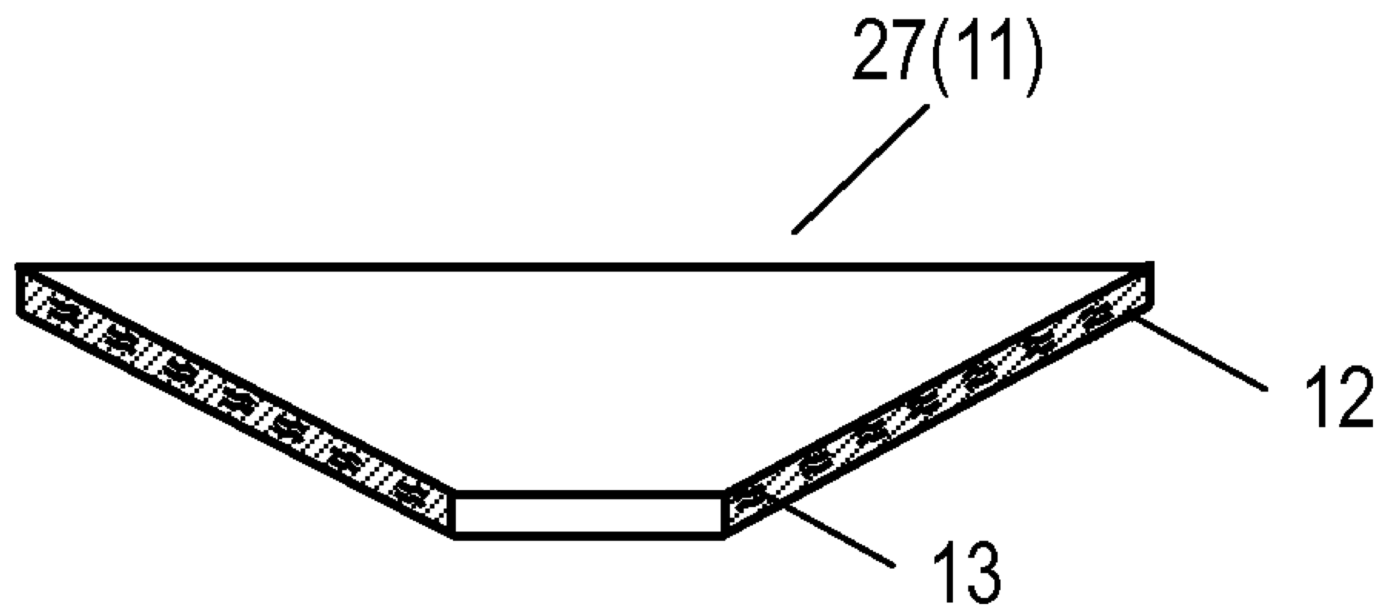


FIG. 6

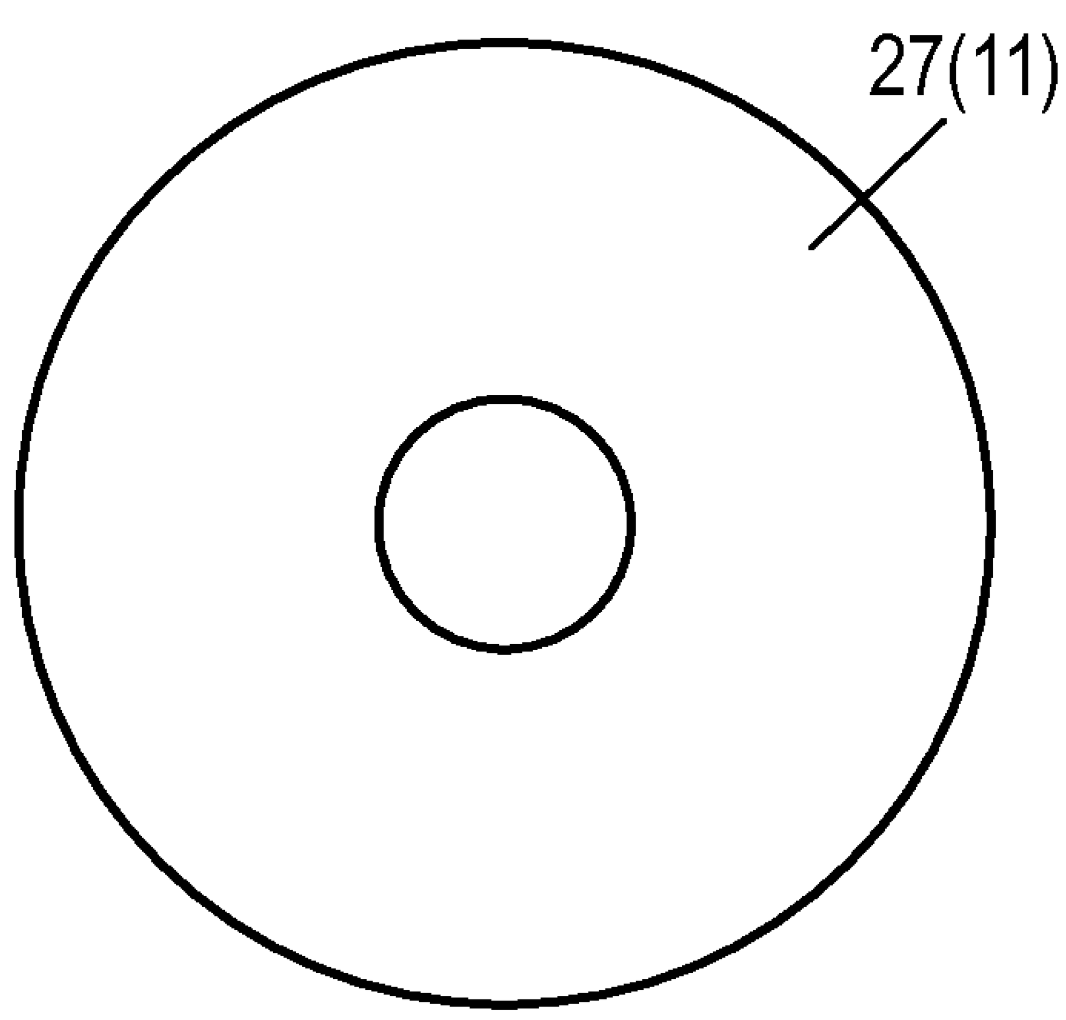


FIG. 7

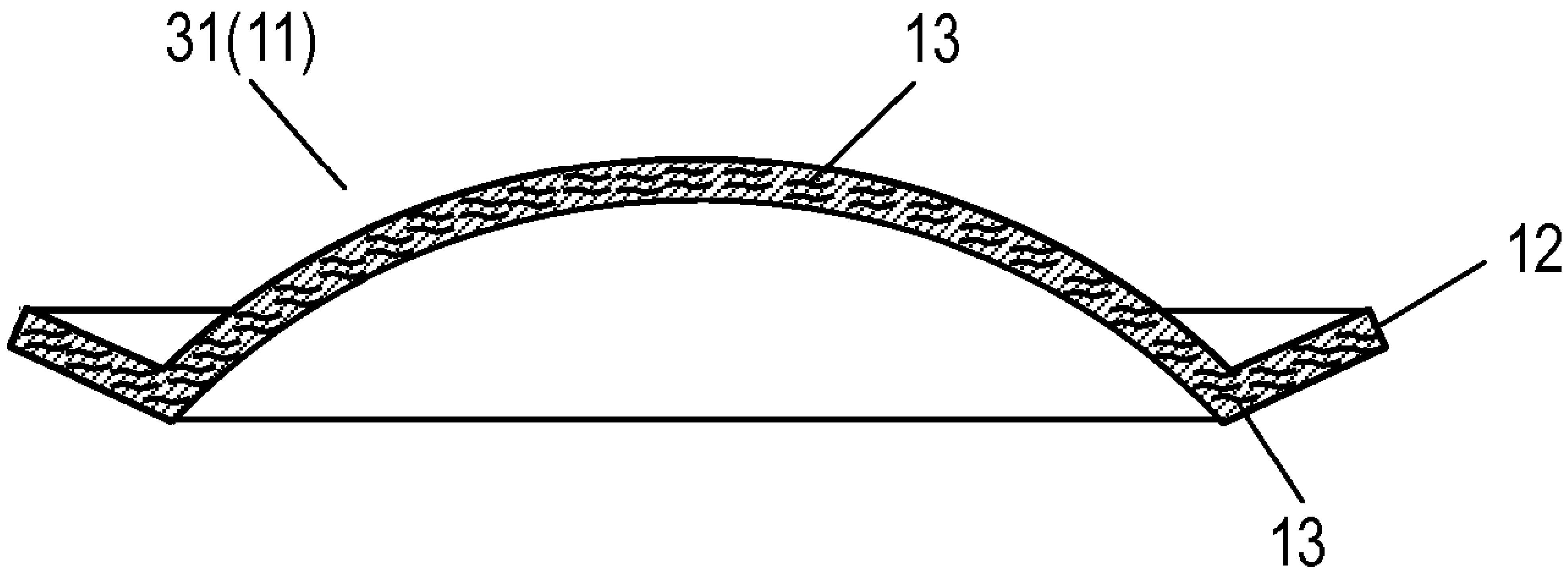


FIG. 8

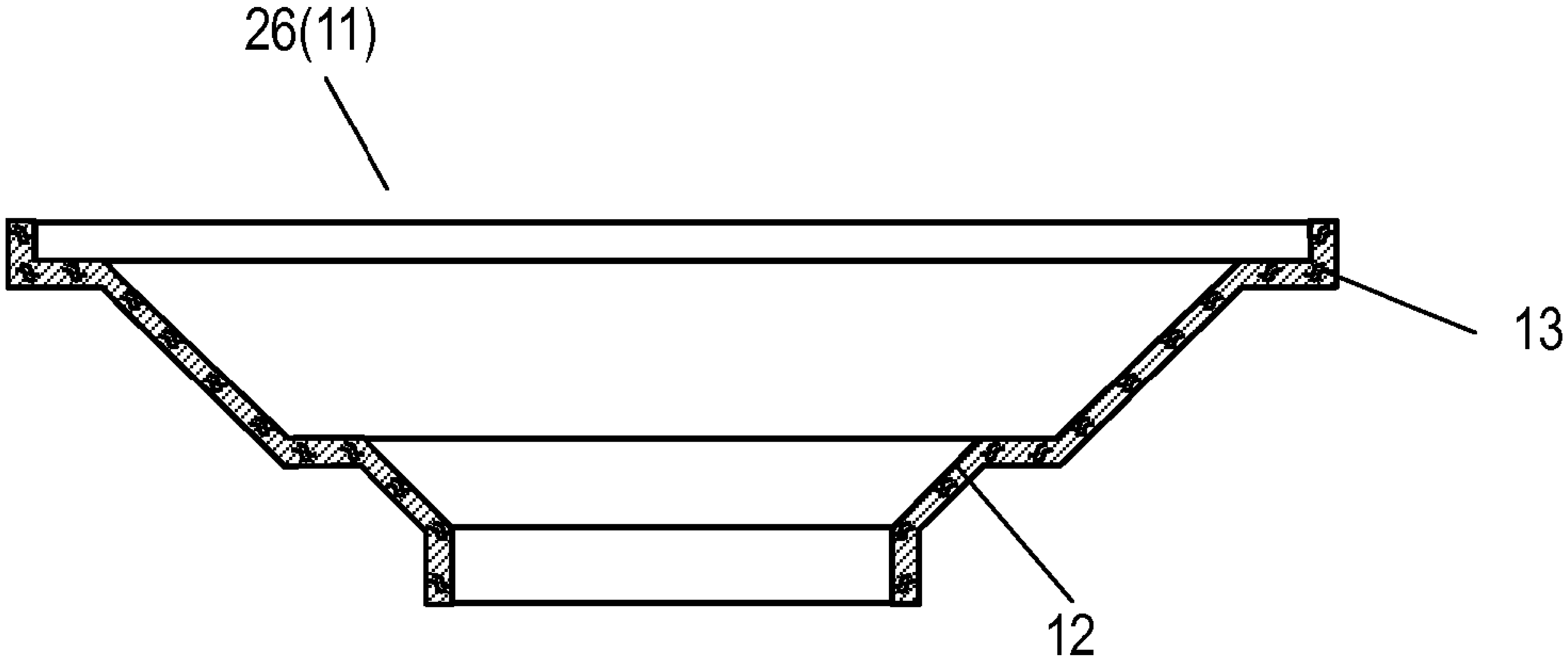


FIG. 9

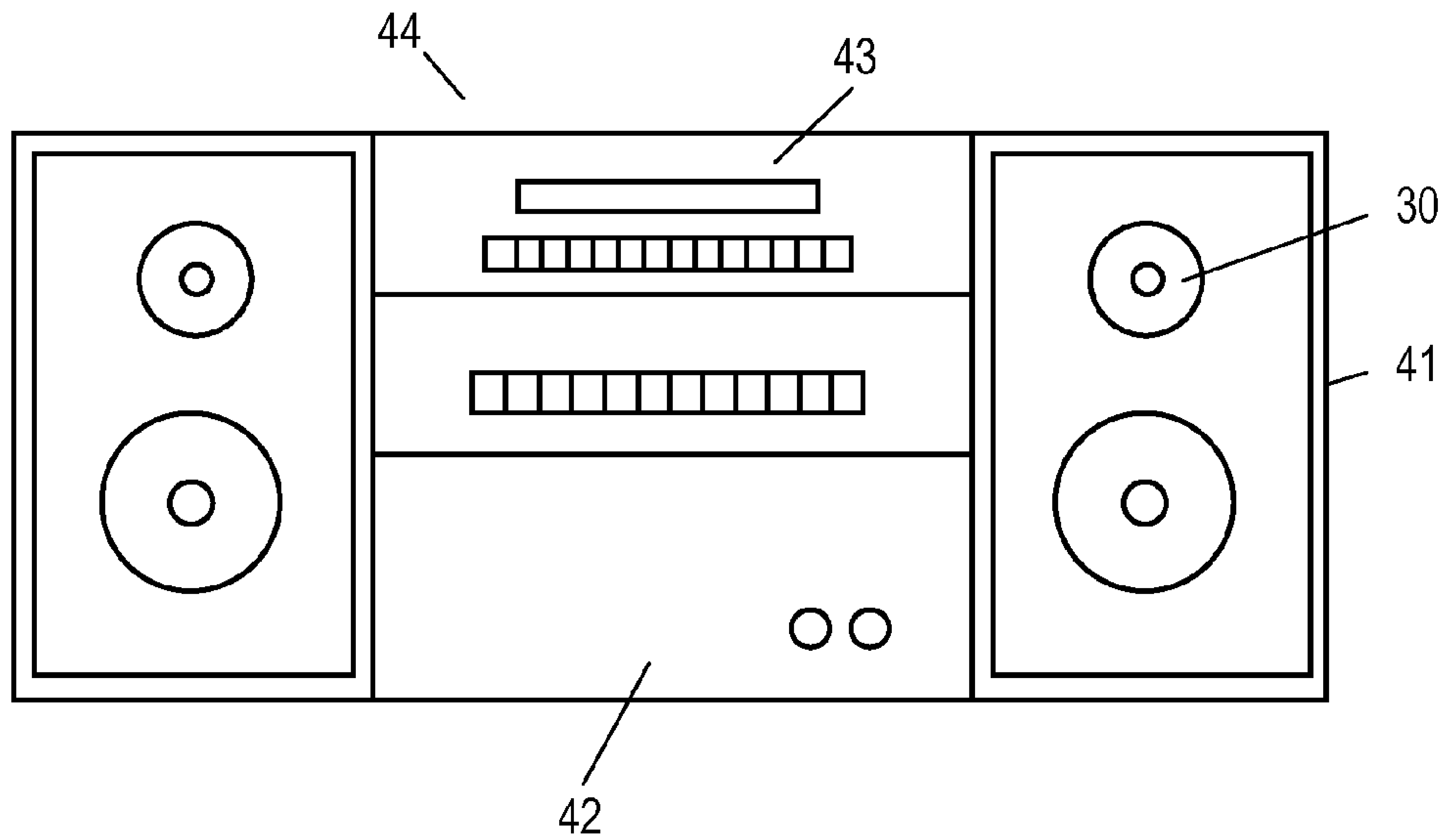
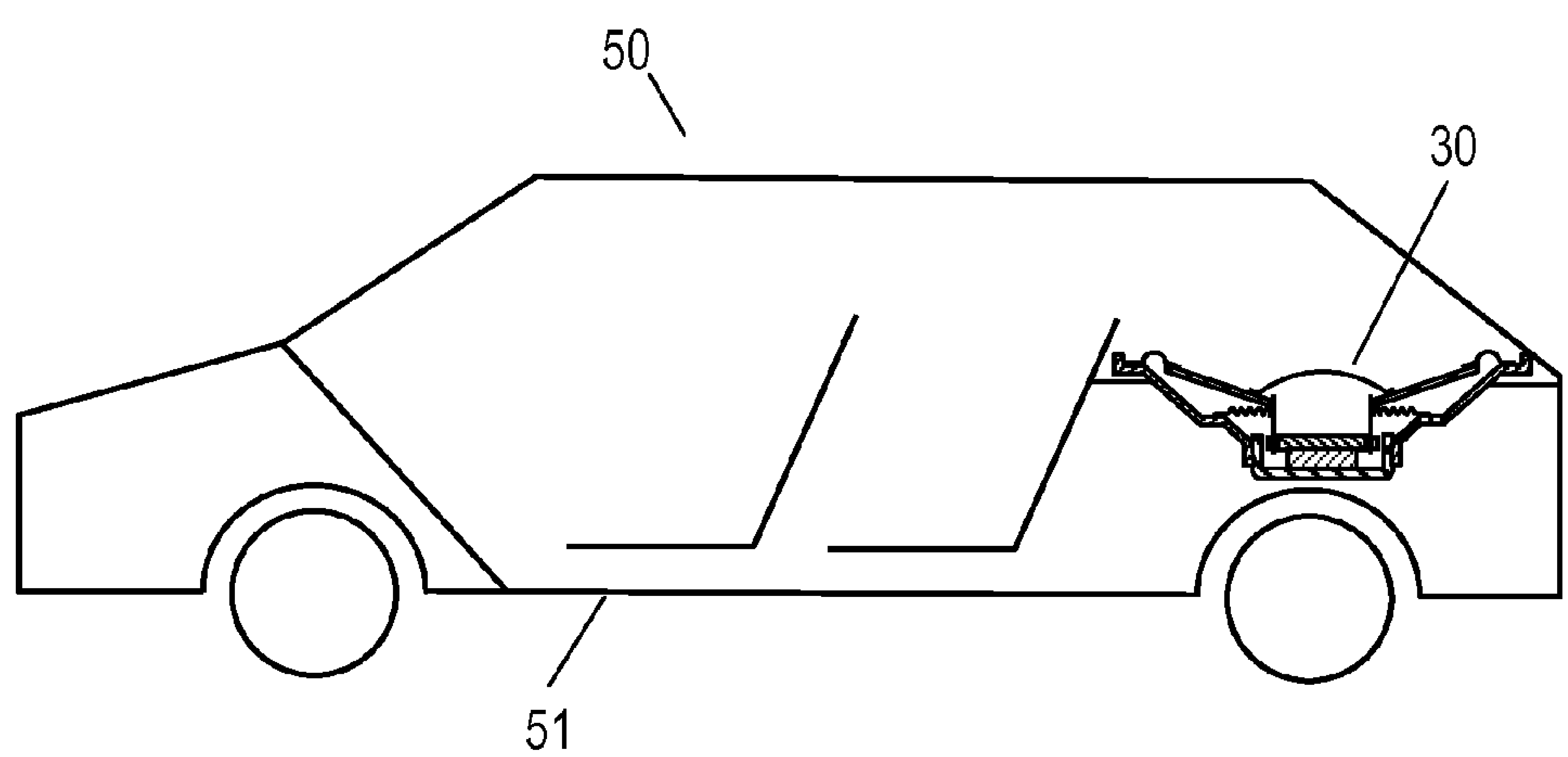


FIG. 10



LOUDSPEAKER RESIN MOLDING COMPONENT AND LOUDSPEAKER USING THE SAME AND ELECTRONIC DEVICE AND MOBILE APPARATUS USING THE LOUDSPEAKER

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of International Application No. PCT/JP2012/002510, filed Apr. 11, 2012, which claims priority of Japanese Patent Application No. 2011-090773, filed Apr. 15, 2011, Japanese Patent Application No. 2011-092692, filed Apr. 19, 2011, and Japanese Patent Application No. 2011-092693, filed Apr. 19, 2011, disclosures of which are hereby incorporated by reference.

BACKGROUND

1. Technical Field

The present technical field relates to a loudspeaker resin molding component used for various loudspeakers, a loudspeaker using the same, an electronic device such as a stereo set or a television set, and a mobile apparatus.

2. Background Art

A conventional loudspeaker resin molding component will be described.

A conventional loudspeaker resin molding component is formed by injection-molding resin such as polypropylene.

This resin material is generally a single material such as polypropylene. By adding reinforcement material such as fibers to this resin, characteristics required for a loudspeaker resin molding component are realized.

SUMMARY

A loudspeaker resin molding component according to various embodiments includes bamboo fibers refined to have a microfibril status and carbonized, and resin.

By the configuration as described above, a loudspeaker resin molding component can have both of high rigidity and high internal loss, thus allowing the loudspeaker to have an improved audio quality. Furthermore, another effect is provided to suppress environment destruction. Furthermore, the degree of freedom for the characteristic of the loudspeaker using the loudspeaker resin molding component and for audio quality adjustment can be increased.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a conceptual diagram illustrating a loudspeaker resin molding component of a first example in Embodiment 1.

FIG. **2** is an SEM observation view showing a microfibril status of bamboo fibers in the loudspeaker resin molding component according to Embodiment 1.

FIG. **3** is a cross-sectional view illustrating a loudspeaker according to Embodiment 1.

FIG. **4** is a conceptual diagram illustrating a loudspeaker resin molding component of a second example in Embodiment 1.

FIG. **5** is a cross-sectional view illustrating a loudspeaker resin molding component of a third example in Embodiment 1.

FIG. **6** is a top view illustrating the loudspeaker resin molding component of the third example in Embodiment 1.

FIG. **7** is a cross-sectional view illustrating a loudspeaker resin molding component of a fourth example in Embodiment 1.

FIG. **8** is a cross-sectional view illustrating a loudspeaker resin molding component of a fifth example in Embodiment 1.

FIG. **9** is an external view illustrating an electronic device according to Embodiment 2.

FIG. **10** is a conceptual diagram illustrating a mobile apparatus according to Embodiment 3.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

(Embodiment 1)

Hereinafter, Embodiment 1 will be described with reference to the drawings. FIG. **1** is a conceptual diagram illustrating a loudspeaker resin molding component of a first example in Embodiment 1.

As shown in FIG. **1**, loudspeaker resin molding component **11** according to Embodiment 1 includes refined carbonized bamboo fibers **13** and resin **12**. Refined carbonized bamboo fibers **13** are bamboo fibers that are refined to have a microfibril status and are carbonized.

By this configuration, refined carbonized bamboo fibers **13** provide a synergetic effect of the effect by fibers refined to have a microfibril status and the effect owned by carbonized fibers. As a result, loudspeaker resin molding component **11** can achieve both of a high elastic modulus and a high internal loss.

The synergetic effect provided by refined carbonized bamboo fibers **13** will be described in detail. Bamboo fibers refined to have a microfibril status have a branched structure as shown in FIG. **2**. The bamboo fiber has thick truncal part **13**A and feathered parts **13**B. Feathered parts **13**B are thin feathered fibers formed on the surface of truncal part **13**A. FIG. **2** is a photograph showing non-carbonized bamboo fibers refined to have a microfibril status. Refined carbonized bamboo fibers **13** also have a structure similar to the above-described one. The structure as described above allows refined carbonized bamboo fibers **13** to have an improved entanglement with resin **12** and other fillers.

Refined carbonized bamboo fibers **13** have a very high hardness. Furthermore, each of refined carbonized bamboo fibers **13** has thick truncal part **13**A. Thus, the high rigidity owned by the carbonized bamboo fibers is maintained even when the fibers are refined to have a microfibril status. Thus, refined carbonized bamboo fibers **13** have a very high hardness. In addition, feathered part **13**B of refined carbonized bamboo fibers **13** is more easily entangled with resin **12** as described above. As a result, loudspeaker resin molding component **11** has much-improved elasticity compared with that of mere bamboo fibers or mere carbide.

Furthermore, since refined carbonized bamboo fibers **13** have many pores (holes), the carbonized bamboo fibers can have a large surface area, thus increasing the area at which the carbonized bamboo fibers contact with resin **12**. This consequently increases the binding capacity between refined carbonized bamboo fibers **13** and resin **12**. Thus, in addition to a further-increased elasticity of loudspeaker resin molding component **11**, loudspeaker resin molding component **11** can have a further-increased internal loss.

However, in the case of the conventional loudspeaker resin molding component, an increased elastic modulus conflicts with an increased internal loss. To solve the above disadvantage, loudspeaker resin molding component **11** according to the embodiment has the above-described configuration so that loudspeaker resin molding component **11** can provide both of a high elastic modulus and a high internal loss and provides high-audio-quality. As a result, loudspeaker resin molding component **11** can reproduce clear sound having a small distortion. Thus, a loudspeaker including loudspeaker resin molding component **11** of this embodiment can have an improved audio quality.

Refined carbonized bamboo fibers **13** are favorably bound to resin **12** or additive agent such as filler. As a result, the material choices of resin **12** and/or filler used for loudspeaker resin molding component **11** can be increased. Thus, a loudspeaker using loudspeaker resin molding component **11** can have increased characteristics or an increased degree of freedom for audio quality adjustment.

Furthermore, the use of refined carbonized bamboo fibers **13** can suppress the environment destruction.

Hereinafter, loudspeaker **30** using the loudspeaker molding component in this embodiment will be described in detail. FIG. **3** is a cross-sectional view illustrating a loudspeaker according to Embodiment 1.

As shown in FIG. **3**, loudspeaker **30** according to this embodiment includes magnetic circuit **24**, frame **26**, diaphragm **27**, voice coil **28**, edge **29** and dust cap **31**.

Magnetic circuit **24** includes magnet **21**, upper plate **22**, and yoke **23**. Magnetic circuit **24** is configured so that magnetized magnet **21** is sandwiched between upper plate **22** and yoke **23**. Magnetic circuit **24** is connected to a lower part of frame **26**.

Edge **29** is adhesively attached to an outer periphery of diaphragm **27**. An outer periphery of edge **29** is adhesively attached to a peripheral edge of frame **26**. By this configuration, diaphragm **27** is connected to frame **25** via edge **29**.

Voice coil **28** is disposed at a back face side (or in the lower direction in FIG. **3**) of diaphragm **27** and at a center of diaphragm **27**. One end of voice coil **28** is connected to diaphragm **27**. The other end of voice coil **28** is inserted in magnetic gap **25** of magnetic circuit **24**.

Dust cap **31** is disposed at a front face side of diaphragm **27** and is connected to the center of diaphragm **27**.

In the case described above, magnetic circuit **24** is an internal magnet-type circuit. However, the magnetic circuit is not limited to this. As magnetic circuit **24**, an external magnet-type circuit is also applicable. When magnetic circuit **24** is an internal magnet-type circuit, yoke **23** is connected to frame **26**. When magnetic circuit **24** is an external magnet-type circuit on the other hand, upper plate **22** is connected to frame **26**.

Loudspeaker resin molding component **11** of this embodiment is diaphragm **27**, frame **26** and dust cap **31**. Specifically, in this embodiment, diaphragm **27**, frame **26**, and dust cap **31** include refined carbonized bamboo fibers **13**. In this embodiment, all of diaphragm **27**, frame **26**, and dust cap **31** include refined carbonized bamboo fibers **13**. However, refined carbonized bamboo fibers **13** also may be used for at least one of diaphragm **27**, frame **26**, and dust cap **31**.

By the above configuration, loudspeaker **30** can have the increased internal loss in addition to the improved rigidity and elastic modulus of loudspeaker resin molding component **11**. Thus, a resonance in loudspeaker resin molding component **11** is reduced so that loudspeaker **30** can clearly reproduce a high tone, and can reproduce sound in a wide range from a low tone range to a high tone range. As a result, loudspeaker **30** in this embodiment can reproduce sound with a further higher audio quality than in the case where mere bamboo fibers are used. Furthermore, since loudspeaker **30** can reproduce sound in an increased sound pressure level, loudspeaker **30** capable of providing a further-increased output can be realized.

Furthermore, since loudspeaker resin molding component **11** has high rigidity and elastic modulus, the destruction of loudspeaker resin molding component **11** is suppressed even when an excessive signal is inputted to loudspeaker **30** or even when loudspeaker resin molding component **11** receives a load or vibration. Thus, highly-reliable loudspeaker **30** can be realized.

Next, loudspeaker resin molding component **11** in this embodiment will be described. FIG. **4** is a conceptual diagram illustrating a loudspeaker resin molding component of a second example in Embodiment 1. In this example, loudspeaker resin molding component **11** includes resin **12**, refined carbonized bamboo fibers **13**, and additive agent **14**. Loudspeaker resin molding component **11** is formed by injection-molding or sheet-molding the bamboo fibers, resin **12**, and additive agent **14**. Thus, loudspeaker resin molding component **11** can have improved productivity and dimensional stability.

In this example, refined carbonized bamboo fibers **13** have a freeness in the range from 0 cc to 37 cc. The relation between the freeness of refined bamboo fibers and the tension strength of the papermaking product using the refined bamboo fibers is shown in Table 1.

TABLE 1

Freeness (cc)	Tension strength (MPa)
550	15
80	33
53	39
37	49
5	50

As shown in Table 1, the papermaking product shows an improved strength by refining bamboo fibers. This shows that the entanglement among the refined bamboo fibers is promoted to thereby improve the strength of the papermaking product. Refined carbonized bamboo fibers **13** also show a similar effect. Thus, the entanglement among refined carbonized bamboo fibers **13** in resin **12** is promoted, thus improving the strength of loudspeaker resin molding component **11**.

When refined carbonized bamboo fibers **13** have a freeness of 550 cc or more, the carbonized bamboo fibers have an insufficient freeness. When refined carbonized bamboo fibers **13** have a freeness of 80 cc, the carbonized bamboo fibers have a sufficient freeness. While a freeness of refined carbonized bamboo fibers **13** is changing from 550 cc to 80 cc, the tension strength of refined carbonized bamboo fibers **13** is gradually increasing.

When refined carbonized bamboo fibers **13** have a freeness lower than 80 cc, the tension strength of refined carbonized bamboo fibers **13** is improved at a relatively-high rate. The tension strength of refined carbonized bamboo fibers **13** is in a saturated status when the freeness is lower than about 37 cc. Specifically, by allowing refined carbonized bamboo fibers **13** to have a freeness in the range between 0 cc to 37 cc, the refined bamboo fibers can provide a stable reinforcement effect to loudspeaker resin molding component **11**. Due to this reason, refined carbonized bamboo fibers **13** in this embodiment have a freeness of 37 cc or less. As a result, even when the material has a different tension strength for example, loudspeaker resin molding component **11** having a stable rigidity can be obtained.

When refined carbonized bamboo fibers **13** have an average fibers diameter larger than 5 μm, an action to promote the entanglement among the fibers is reduced. Thus, refined carbonized bamboo fibers **13** are suppressed from realizing a superior characteristic in loudspeaker resin molding component **11**. Thus, in this embodiment, refined carbonized bamboo fibers **13** have an average fibers diameter smaller than 5 μm and have an L/D (average fiber length/average fiber diameter) of 10 or more. As a result, refined carbonized bamboo fibers **13** are favorably entangled with resin **12** and/or additive agent **14** such as filler. This consequently can realize loudspeaker resin molding component **11** having a high rigidity.

In this embodiment, refined carbonized bamboo fibers **13** can be manufactured by a mixer, a beater, a refiner, a pressure-type homogenizer, an ultrasonic homogenizer, a crusher using beads composed of glass or zirconia as raw material, or an uniaxial or multiaxis extruder, for example.

Refined carbonized bamboo fibers **13** are desirably obtained by a high carbonization temperature of 500° C. or more. By the carbonization at a temperature of 500° C. or more, hard refined carbonized bamboo fibers **13** can be obtained.

Refined carbonized bamboo fibers **13** are desirably mixed in an amount at 3 weight % or more and 30 weight % or less. If refined carbonized bamboo fibers **13** are included in an amount lower than 3 weight %, the action to improve the bending elastic modulus of loudspeaker resin molding component **11** is small. When refined carbonized bamboo fibers **13** are included in an amount exceeding 30 weight % on the other hand, it is difficult to allow the refined bamboo fibers to be evenly dispersed in resin **12**. Furthermore, fluidity of refined carbonized bamboo fibers **13** is deteriorated, thus making it difficult to mold loudspeaker resin molding component **11** having a thin thickness by injection molding.

Therefore, the effect of refined carbonized bamboo fibers **13** as described above can be most effectively achieved by allowing refined carbonized bamboo fibers **13** to be included in an amount of 3 weight % or more and 30 weight % or less.

Refined carbonized bamboo fibers **13** may be obtained from any bamboo as long as the bamboo is a Bambusaceous plant except for bamboo having an age of 1 year or less and a bamboo shoot. As described above, loudspeaker resin molding component **11** is formed by refined carbonized bamboo fibers **13** obtained from bamboo having an age of 1 year or more. As a result, loudspeaker resin molding component **11** can secure acoustic characteristics required for loudspeaker resin molding component **11** (e.g., high rigidity, strength, large internal loss). Refined carbonized bamboo fibers **13** made from bamboo having an age of 2 years or more have slightly-increased rigidity and strength depending on the age. Thus, refined carbonized bamboo fibers **13** obtained from bamboo having an age of 1 year or more are used in this embodiment.

Generally, trees for wood material such as needle-leaf trees and broad-leaf trees require 40 or more years to grow. Thus, once such trees are cut down, forest requires a very long time to regenerate. Therefore, an excessive tree trimming causes environment destruction. On the other hand, bamboos grow very fast compared with needle-leaf trees and broad-leaf trees. Thus, one year or more is sufficient for bamboo forest to regenerate to a level similar to that before the trimming, thus suppressing the nature destruction of the bamboo forest. Thus, bamboo is a very effective material from the view point of the use of a limited resource on the earth. As described above, loudspeaker resin molding component **11** using bamboo can suppress the environment destruction compared with the one using wood. Furthermore, since one year or more is sufficient for bamboo forest to regenerate, refined carbonized bamboo fibers **13** can be obtained in a stable, continuous, and low-cost manner. Therefore, low-cost loudspeaker resin molding component **11** can be provided.

As same as the refined non-carbonized bamboo fibers shown in FIG. **2**, refined carbonized bamboo fibers **13** have thick truncal part **13**A. Thus, even in a carbonized status, the high rigidity owned by bamboo fibers is not lost, thus refined carbonized bamboo fibers **13** provides a very-high hardness. In addition, refined carbonized bamboo fibers **13** allow feathered part **13**B to be easily entangled with resin **12** and/or additive agent **14** such as filler. As a result, loudspeaker resin molding component **11** has such a rigidity that is significantly improved than in the case where mere refined bamboo fibers or mere carbonized fibers are used.

Furthermore, refined carbonized bamboo fibers **13** are carbonized at a high temperature (a temperature at least 500° C. or more). Thus, refined carbonized bamboo fibers **13** include therein many pores (holes). This consequently provides a further improved entanglement with resin **12** and filler. Furthermore, pores (mainly on the surface) of refined carbonized bamboo fibers **13** are filled with resin **12**. As a result, refined carbonized bamboo fibers **13** contact with resin **12** in an increased area. Therefore, loudspeaker resin molding component **11** can have increased rigidity and elastic modulus as well as an increased internal loss compared with a loudspeaker resin molding component using mere refined bamboo fibers or mere carbonized fibers.

If refined carbonized bamboo fibers **13** are carbonized at a further higher temperature (800° C. or more), refined carbonized bamboo fibers **13** include therein more pores. Thus, loudspeaker resin molding component **11** can have the further increased rigidity and elastic modulus and the further increased internal loss.

As described above, loudspeaker resin molding component **11** including refined carbonized bamboo fibers **13** can realize both of a high rigidity and a large internal loss by the synergetic effect of the carbonization and refining of the bamboo fibers. As a result, loudspeaker resin molding component **11** can reduce an undesired resonance, reduce distortion, improve the sound pressure, and expand the reproduction band, thus providing loudspeaker **30** having a higher audio quality.

Generally, when non-refined carbonized material is used, this carbonized material has a low affinity for resin material, thus suppressing the carbonized material from effectively functioning as reinforcing material. In such a case, the unrefined carbonized material must be subjected to a surface processing (e.g., silane processing). However, refined carbonized bamboo fibers **13** have an anchor effect of feathered part **13**B with respect to resin **12** and additive agent **14**. This consequently causes an increased affinity between refined carbonized bamboo fibers **13**, and resin **12** and additive agent **14**, thus improving the mechanical adhesiveness between refined carbonized bamboo fibers **13**, and resin **12** and additive agent **14**. Thus, loudspeaker resin molding component **11** having a high rigidity can be obtained.

In view of the above, refined carbonized bamboo fibers **13** in this embodiment are not subjected to a surface processing. As described above, the surface processing step of refined carbonized bamboo fibers **13** also can be deleted or simplified. This can consequently reduce the number of the steps for the surface processing of refined carbonized bamboo fibers **13**, thus providing low-cost loudspeaker resin molding component **11**. If refined carbonized bamboo fibers **13** are subjected to a surface processing, the mechanical adhesiveness between refined carbonized bamboo fibers **13**, and resin **12** and additive agent **14** can be further improved. In this case, loudspeaker resin molding component **11** having a further-higher rigidity can be obtained.

When resin **12** is poorly bound to additive agent **14**, loudspeaker resin molding component **11** cannot obtain desired characteristics (e.g., strength, elastic modulus, internal loss). For example, polypropylene resin (nonpolar) is poorly bound to polar additive agent **14**. In the present embodiment, refined carbonized bamboo fibers **13** are entangled with resin **12** and additive agent **14**, thereby increasing the binding capacity with resin **12** and additive agent **14**. Thus, loudspeaker resin molding component **11** can employ a wider range of materials. As a result, loudspeaker resin molding component **11** can realize a conventionally-unachievable characteristic and a wide range of audio qualities.

As described above, loudspeaker resin molding component **11** can allow the loudspeaker to have a wider range of audio qualities while retaining the moisture resistance and water resistance of the resin. Furthermore, loudspeaker **30** can handle a high output, has a superior appearance, and can improve the productivity. Thus, loudspeaker **30** using loudspeaker resin molding component **11** can be mounted to an acoustic device outputting a high volume, an acoustic device for an outdoor use, and an automobile, in addition to a general electronic device, thus increasing the applications of loudspeaker **30**.

Next, additive agent **14** will be described. In order to reproduce required sound, loudspeaker resin molding component **11** is added with various additive agents **14**. Additive agents **14** are added as reinforcement material of loudspeaker resin molding component **11**. Example of additive agents **14** includes natural fibers, mica, graphite, talc, calcium carbonate, clay, carbon fibers, and aramid fibers.

Any natural fibers may be used such as wood fibers or non-wood fibers. Wood fibers may be obtained from needle-leaf trees or broad-leaf trees for example. Non-wood fibers may be obtained from non-wood material such as bamboos, kenaf, jute, Manila hemp, and gampi. Trees such as Needle-leaf trees and broad-leaf trees require 40 or more years to grow. Thus, once such trees are cut down, forest requires a very long time to regenerate. Thus, an excessive tree trimming causes environment destruction. On the other hand, non-wood materials grow very fast compared with needle-leaf trees and broad-leaf trees, thus suppressing the nature destruction.

Generally, non-wood fibers are tough and rigid compared with wood fibers. Thus, loudspeaker resin molding component **11** added with non-wood fibers can have an increased rigidity, thus providing the reproduction of a clear audio quality free from distortion, and of clear sound.

When non-carbonized fibers of bamboo (hereinafter referred to as non-carbonized bamboo fibers) are used in particular, loudspeaker resin molding component **11** can have a further-increased rigidity. The reason is that non-carbonized bamboo fibers also have a high rigidity and a light weight as same as carbonized bamboo fibers. In this case, when bamboo fibers (combination of non-carbonized bamboo fibers and refined carbonized bamboo fibers **13**) are mixed at a ratio lower than 3 weight %, the effect by the bamboo fibers are substantially suppressed from appearing. When the bamboo fibers are mixed at a ratio higher than 60 weight % on the other hand, a long time is required to knead the bamboo fibers and resin **12** and injection molding may be difficult. This consequently causes a reduced productivity of loudspeaker resin molding component **11**. Furthermore, since loudspeaker resin molding component **11** has a declined dimensional stability, loudspeaker resin molding component **11** has a reduced degree of freedom in shape.

Therefore, bamboo fibers are desirably mixed in resin **12** in an amount of 3 weight % or more and 60 weight % or less. By mixing the bamboo fibers in resin **12** in an amount within the above ratio, the bamboo fibers can provide the effect efficiently and can improve the productivity and quality.

By including bamboo fibers in an amount exceeding 51 weight %, loudspeaker resin molding component **11** can be incinerated and disposed in contrast with a conventional loudspeaker resin molding component formed only by petroleum-derived resin **12**.

Non-carbonized bamboo fibers desirably have a freeness in a range from 0 cc to 37 cc, inclusive. When non-carbonized bamboo fibers refined to such a level are compared with not-refined non-carbonized bamboo fibers, the former has a higher elastic modulus. Furthermore, the existence of feathered part **13**B improves the binding among refined non-carbonized bamboo fibers and the binding between refined non-carbonized bamboo fibers and refined carbonized bamboo fibers **13**. Thus, the synergetic effect of the above factors allows loudspeaker resin molding component **11** added with refined non-carbonized bamboo fibers to have a higher elastic modulus than that of loudspeaker resin molding component **11** added with non-refined non-carbonized bamboo fibers.

Non-carbonized bamboo fibers may be partially or entirely substituted with a bamboo powder. The use of the bamboo powder allows loudspeaker **30** to output more natural and clearer sound.

Alternatively, non-carbonized bamboo fibers may be partially or entirely substituted with (not-refined) pulverized bamboo charcoal. This configuration can allow loudspeaker resin molding component **11** to have increased elastic modulus and internal loss. The pulverized bamboo charcoal is obtained by carbonizing bamboo pieces cut to have an appropriate length at a temperature of about 500° C. or more, then pulverizing the carbonized bamboo pieces. The pulverized bamboo charcoal desirably has a particle diameter of 150 μm or less. The pulverized bamboo charcoal having a particle diameter larger than 150 μm makes it difficult to disperse the pulverized bamboo charcoal in resin **12**, thereby causing a tendency where loudspeaker resin molding component **11** has a defective appearance or variation in quality. The pulverized bamboo charcoal preferably has a particle diameter close to the size of refined carbonized bamboo fibers **13**. By doing this, the pulverized bamboo charcoal is dispersed in resin **12** or refined carbonized bamboo fibers **13** in a favorable manner.

When mica is added as additive agent **14**, loudspeaker resin molding component **11** can have an increased elastic modulus. When graphite is added, loudspeaker resin molding component **11** can have increased elastic modulus and internal loss. When talc, calcium carbonate, and clay are added, loudspeaker resin molding component **11** can have an increased internal loss. When aramid fibers are added, the entanglement between refined carbonized bamboo fibers **13** and the aramid fibers can allow loudspeaker resin molding component **11** to have an increased internal loss without causing a decrease in the elastic modulus of loudspeaker resin molding component **11**. When aramid fibers refined to a microfibril status are added, the entanglement between and refined carbonized bamboo fibers **13** and the aramid fibers refined to a microfibril status is further increased, thus providing loudspeaker resin molding component **11** having a further-higher elastic modulus and a further-larger internal loss. Alternatively, as chemical fibers, fibers having a high strength and a high elastic modulus fibers like carbon fibers also may be used.

Next, resin **12** will be described. Resin **12** is desirably olefin resin. Each of polymethylpentene and polypropylene has a small specific gravity. Thus, the use of such resin having a small specific gravity also can reduce the weight of loudspeaker resin molding component **11**. Polypropylene in particular is crystalline resin that has a relatively-high heat resistance and good moldability.

Depending on an application, crystalline resin and non-crystalline resin are used as resin **12**. When a high heat resistance or a high solvent resistance is required, engineering plastic is used as resin **12**. As a result, loudspeaker resin molding component **11** utilizing the property value of the resin material can be obtained.

Alternatively, plant-derived resins can be used as resin **12** to be considerate to the environment. Among the plant-derived resins, polylactic acid in particular is highly compatible with refined carbonized bamboo fibers **13** than in the case of polypropylene. Refined carbonized bamboo fibers **13** also promote the crystallization of polylactic acid. Thus, loudspeaker resin molding component **11** can have further-improved strength and heat resistance. Furthermore, molding manhours (cooling time) can be reduced, thus providing low-cost loudspeaker resin molding component **11**.

Furthermore, when mica or talc is added as additive agent **14**, mica or talc functions as crystallization promoter, thus further promoting the crystallization of polylactic acid. In this embodiment, refined carbonized bamboo fibers **13** also promote the crystallization of polylactic acid. Thus, a reduced amount of crystallization promoter such as mica or talc can be added, thus achieving loudspeaker resin molding component **11** having a lighter weight.

Polypropylene is nonpolar resin. Thus, polypropylene may be added with compatibilizer. In this case, an improved compatibility can be provided between nonpolar resin **12** and refined carbonized bamboo fibers **13**. This can consequently improve the binding between resin **12** and refined carbonized bamboo fibers **13** and can improve the elastic modulus and the heat resistance of loudspeaker resin molding component **11**.

In particular, a compatibilizer may be silane having a vinyl group, a methacryloxy group, or a mercapto group. Such a compatibilizer includes vinyltrimethoxy silane, vinyltriethoxy silane, 3-methacryloyloxypropylmethyldimethoxy silane, 3-methacryloxypropyltrimethoxy silane, 3-methacryloxypropylmethyldiethoxy silane, 3-methacryloxypropyltriethoxy silane, 3-mercapto propylmethyldimethoxy silane, and 3-mercapto propyltrimethoxysilane.

The compatibilizer is not limited to this. Thus, other silane coupling agents also may be used. Alternatively, nonpolar resin **12** may be denatured by maleic anhydride, for example, to allow resin **12** to be polar. When polylactic acid is used as resin **12**, tannin may be used as the compatibilizer.

Refined carbonized bamboo fibers **13** are more highly compatible with resin **12** than non-refined bamboo fibers, thus allowing a reduced amount of the compatibilizer to be used.

As described above, according to loudspeaker resin molding component **11** of the present embodiment, refined carbonized bamboo fibers **13** also function as a compatibilizer. Thus, by appropriately combining these materials, loudspeaker resin molding component **11** can have a wide range of property values. Therefore, loudspeaker **30** having a wide range of audio qualities can be obtained by combining selected loudspeaker resin molding components **11**.

Since refined carbonized bamboo fibers **13** are black, it is not needed to add coloring agent such as the black one.

FIG. **5** is a cross-sectional view illustrating a loudspeaker resin molding component of a third example in Embodiment 1. FIG. **6** is a top view illustrating the loudspeaker resin molding component of the third example in Embodiment 1. Loudspeaker resin molding component **11** in this example is diaphragm **27**.

As shown in FIG. **5** and FIG. **6**, diaphragm **27** in this example is obtained by injection molding material including resin **12** and refined carbonized bamboo fibers **13**. Alternatively, diaphragm **27** may be formed by sheet molding. Furthermore, diaphragm **27** also may be added with additive agent **14** as shown in FIG. **4**. Diaphragm **27** in this example may use any of the configurations of loudspeaker resin molding component **11** in the second example.

This configuration can allow diaphragm **27** to have a sufficient rigidity and high toughness. Since the refined carbonized bamboo fibers have a very-small specific gravity, diaphragm **27** can have a very-light weight. As a result, diaphragm **27** can have improved rigidity and sound speed, thus reducing the distortion of diaphragm **27**. By these configurations, diaphragm **27** can have an improved sound pressure level and an improved audio quality (e.g., an expanded high-pass limiting frequency). Diaphragm **27** in this embodiment shows a remarkably-improved sound pressure level in a high range.

Diaphragm **27** provides both of improved elastic modulus and internal loss by including refined carbonized bamboo fibers **13**. Specifically, by being both refined and carbonized, refined carbonized bamboo fibers **13** provide a synergetic effect. Thus, diaphragm **27** can have an increased reproduction band and thus diaphragm **27** can reproduce clear sound in a wide frequency range. Specifically, the resonance caused by an insufficient rigidity of a diaphragm can be reduced and a clear and high sound pressure level can be obtained with a low distortion in a high tone range. Furthermore, favorable low-frequency sound can be also reproduced in a favorable low tone range.

In refined carbonized bamboo fibers **13**, more pores are generated with an increase of the carbonization temperature. Thus, refined carbonized bamboo fibers **13** used for diaphragm **27** of this example are carbonized at a temperature of 800° C. or more. This consequently generates an increased number of pores, thus increasing the internal loss. Since refined carbonized bamboo fibers **13** are hard, diaphragm **27** can have a high elastic modulus. Therefore, diaphragm **27** can achieve both of a high elastic modulus and a high internal loss.

By the widespread use of digital techniques in recent years, electronic devices such as an acoustic device and a video device have a higher audio quality. Thus, loudspeaker **30** shown in FIG. **3** used for the electronic devices is required to provide an improved performance. On the other hand, among components constituting the loudspeaker, diaphragm **27** is the most important determinant factor regarding the performance and audio quality of loudspeaker **30**. Thus, the use of diaphragm **27** can provide loudspeaker **30** that can realize a high audio quality satisfying the market need.

A conventional resin-made diaphragm has a disadvantage that a loudspeaker characteristic and an audio quality adjustment range are extremely narrow. Furthermore, a diaphragm composed of the combination of resin and pulp material have to have an increased strength in order to improve the audio quality of the diaphragm.

Thus, the present embodiment uses the above-described configuration to solve the above disadvantage. Specifically, the embodiment allows diaphragm **27** to have an increased degree of freedom of a strength and an internal loss value and allows loudspeaker **30** to have an increased degree of freedom for characteristics and the audio quality adjustment. Furthermore, diaphragm **27** can secure the moisture resistance reliability and a superior appearance. In addition, diaphragm **27** can have an improved productivity.

Next, how to create the characteristics and sound of loudspeaker **30** will be described. Diaphragm **27** is prepared by combining various materials such as resin or additive agent so as to have desired property value and audio quality. In order to realize the characteristics of diaphragm **27** (characteristics creation) and audio quality (sound creation), know-hows are required. However, such creations are generally carried out by the method as shown below. Specifically, the characteristics and sound of loudspeaker **30** are created by changing the parameter of the components of loudspeaker **30**.

For example, in a case where, among the components of loudspeaker **30**, the parameters of the other components other than diaphragm **27** are fixed, how to create the characteristic and sound of loudspeaker **30** will be described.

Variable parameters of diaphragm **27** include a material property value of diaphragm **27** itself as well as the area, shape, weight, thickness of diaphragm **27** and the like. The sound pressure frequency characteristics and the audio quality of the loudspeaker are generally determined based on conditions other than the material property value of diaphragm **27**. However, the specification of diaphragm **27** such as the area, shape, weight, and thickness is substantially determined by a customer requirement or the like at an initial stage for designing loudspeaker **30**.

Then, diaphragm **27** is prepared based on the determined specification (e.g., area, shape, weight, thickness). However, diaphragm **27** in many cases causes undesired peak or dip in the sound pressure frequency characteristics. As a result, at a specific frequency range, diaphragm **27** has a high distortion or an audio quality significantly depending on the sound pressure frequency characteristics. These distortion and sound pressure frequency characteristics are generally caused by the area, shape, weight, or thickness of diaphragm **27** and are determined by the vibration mode of diaphragm **27**, in particular. In order to suppress the undesired peak or dip or distortion to obtain a favorable audio quality, material used for diaphragm **27** is selected.

Hereinafter, a method of selecting material used for diaphragm **27** will be described. Diaphragm **27** in this example includes, as shown in FIG. **4**, resin **12**, refined carbonized bamboo fibers **13**, and additive agent **14**. Thus, resin **12** and additive agent **14** are firstly selected so as to seem to satisfy the sound pressure frequency characteristic, the audio quality, or the reliability for example required for the loudspeaker.

Material for resin **12** is selected so that diaphragm **27** to be formed provides sound close to that when 100% resin **12** is used for forming a diaphragm. However, since loudspeaker **30** generates heat, it is necessary to select material for resin **12** in consideration of a heat resistance reliability.

When resin **12** and additive agent **14** are selected and adding amount of resin **12**, refined carbonized bamboo fibers **13**, and additive agent **14** are determined, the selection and determination are carried out in consideration of the density, elastic modulus, internal loss, and timbre (tone color) which are unique to the respective materials, and the resonance frequencies due to the individual materials when the materials are molded to have the shape of diaphragm **27**.

For example, when an undesired peak or dip is caused in the sound pressure frequency characteristics, a method of suppressing the peak or the dip will be described.

In order to suppress the dip of diaphragm **27**, such resin material is selected that has a resonance frequency at a frequency including the dip. In order to suppress the peak of diaphragm **27** on the contrary, material such as additive agent **14** is selected that has an internal loss in the frequency including the peak.

Next, a master batch pellet is prepared that is highly filled with selected resin **12**, refined carbonized bamboo fibers **13**, and additive agent **14**. Diaphragm **27** is prepared by injection molding this master batch pellet.

With regard to diaphragm **27** thus obtained, the property values and the like are measured and evaluated. Furthermore, diaphragm **27** is used to form the loudspeaker as shown in FIG. **3** as an example. Then, the characteristics and the audio quality are actually measured and the resultant sound is listened for final evaluation. When a desired characteristic or audio quality are not provided in this evaluation, the sample preparation process is performed again. By such trial and error, optimal material and the mixing ratio thereof are determined.

As shown in FIG. **5** and FIG. **6**, diaphragm **27** is formed by injection molding or sheet molding material obtained by mixing resin **12** with refined carbonized bamboo fibers **13**. This configuration achieves both of a high elastic modulus and a large internal loss, thus allowing diaphragm **27** to generate peak or dip relatively few. Therefore, a reduced number of sample preparations are required to select resin **12** and to determine the type and adding amount of additive agent **14**.

FIG. **7** is a cross-sectional view illustrating a loudspeaker resin molding component in a fourth example of Embodiment 1. Loudspeaker resin molding component **11** of the fourth example in this embodiment is dust cap **31**.

As shown in FIG. **7**, dust cap **31** in this example is formed by injection molding the material obtained by mixing resin **12** with refined carbonized bamboo fibers **13**. Additive agent **14** as shown in FIG. **4** also may be added. Dust cap **31** also may be formed by sheet molding. Dust cap **31** in this example also may use any configuration of loudspeaker resin molding component **11** in the first or second example.

By this configuration, dust cap **31** can have a sufficient rigidity and a high toughness. Specifically, the synergetic effect is provided by refining of the bamboo fibers and the carbonization thereof. Furthermore, the refined carbonized bamboo fibers have a very-small specific gravity, thus allowing dust cap **31** to have a very-light weight. As a result, dust cap **31** can have improved rigidity and sound speed, thus reducing the distortion of dust cap **31**. By these configurations, dust cap **31** can have an improved audio quality (e.g., an improved sound pressure level in a high tone range, an expanded limiting frequency at the high range side).

Furthermore, loudspeaker **30** using dust cap **31** can reproduce clear sound. Specifically, the resonance caused by an insufficient rigidity of dust cap **31** can be reduced. Furthermore, loudspeaker **30** providing a clear and high sound pressure level with a low distortion in a high tone range can be realized.

By the widespread use of digital techniques in recent years, electronic devices such as an acoustic device and a video device have a higher audio quality. Thus, loudspeaker **30** as shown in FIG. **3** used for the electronic devices is required to provide an improved performance. Meanwhile, among the performance and the audio quality of loudspeaker **30**, dust cap **31** is an important determinant factor regarding the reproduction of high tone range sound. Thus, the use of dust cap **31** can provide loudspeaker **30** that can reproduce high tone range sound with a high audio quality satisfying the market need.

Dust cap **31** mainly contributes to the reproduction of a high tone. Thus, dust cap **31** is not required to have flat sound pressure characteristics in a wide reproduction frequency range, less than diaphragm **27**. In other words, dust cap **31** may have a lower internal loss than that of diaphragm **27**. Thus, refined carbonized bamboo fibers **13** in this example are carbonized at a temperature of 500° C. or more.

Among the reproduction bands of the loudspeaker, the dust cap performs a high tone-range reproduction band from among a medium-to-high tone range, in particular. Refined bamboo fibers and refined carbonized bamboo fibers **13** provide favorable characteristics and audio quality from a medium-to-high tone range to a high tone range. Thus, refined bamboo fibers and refined carbonized bamboo fibers **13** are optimal material to be added to dust cap **31** from these viewpoints.

Refined bamboo fibers and refined carbonized bamboo fibers **13** have a very high hardness. Refined bamboo fibers and refined carbonized bamboo fibers **13** have feathered part **13**B as shown in FIG. **2** and thus are easily entangled with resin **12** and the additive agent. Thus, this provides an effect to increase the rigidity of dust cap **31** and to significantly improve the high-range characteristics.

A subcone has a reproduction band similar to that of dust cap **31** described in this example. Thus, as shown in FIG. **4**, resin **12**, refined carbonized bamboo fibers **13**, and additive agent **14** also may be used to manufacture a subcone. The subcone in this case also can provide the same effect as that of dust cap **31**.

FIG. **8** is a cross-sectional view illustrating a loudspeaker resin molding component in a fifth example of Embodiment 1. Loudspeaker resin molding component **11** in this example is frame **26**.

As shown in FIG. **8**, frame **26** is formed by injection molding the material obtained by mixing resin **12** with refined carbonized bamboo fibers **13**. Additive agent **14** as shown in FIG. **4** also may be added to the material. Frame **26** also may be formed by sheet molding. Frame **26** in this example may use any configuration of loudspeaker resin molding component **11** in the second example.

By this configuration, the synergetic effect is provided by refining of the bamboo fibers and the carbonization thereof. Specifically, frame **26** can have sufficient rigidity and high toughness. Furthermore, in addition to improved rigidity and high toughness, the internal loss also can be improved. This consequently provides a higher damping by frame **26** to thereby suppress an undesired resonance of frame **26**, thus providing a favorable audio quality having reduced distortion. As a result, loudspeaker **30** shown in FIG. **3** can reproduce sound having a favorable audio quality.

Refined carbonized bamboo fibers **13** are resistant to moisture. Thus, frame **26** having a high moisture resistance reliability can be realized. Furthermore, since frame **26** can be formed by injection molding or sheet molding, frame **26** can have a good appearance and a high productivity.

A conventional loudspeaker frame is formed by metal or resin. In the case of a conventional loudspeaker frame formed by metal, for example, an iron plate or an aluminum die casting is used. However, a frame obtained by the iron plate or aluminum die casting has a very high weight.

A conventional loudspeaker frame using resin on the other hand has a low rigidity. Thus, in order to provide an increased strength to the conventional loudspeaker frame, the conventional loudspeaker frame using resin is added with inorganic fillers such as glass fibers or mica. Generally, in order to satisfy the acoustic performance, inorganic filler of a weight ratio of 30% or more is added to the frame. However, the addition of the inorganic filler causes an increased specific gravity, thus causing the frame to have an increased weight. When glass fibers are used in order to improve the shock resistance on the other hand, a risk of environment destruction may be caused.

In view of the above, frame **26** in this embodiment is formed of resin **12** to be added with refined carbonized bamboo fibers **13**. Resin **12** and refined carbonized bamboo fibers **13** are hard and has a very-small specific gravity. This can consequently increase the strength of frame **26** and can reduce the weight of frame **26**. Thus, when frame **26** is mounted in a mobile apparatus (shown in FIG. **10**), which will be described later, in particular, frame **26** can contribute to an improvement of fuel consumption, running performance and the like of the mobile apparatus. The use of refined carbonized bamboo fibers **13** suppresses the environment destruction.

Generally, frame **26** may have a lower internal loss than that of diaphragm **27**. Thus, refined carbonized bamboo fibers **13** in this example may be carbonized at a temperature of 500° C. or more.

Although polypropylene is used as resin **12** used for frame **26** in this example, resin **12** is not limited to polypropylene. For example, resin **12** used for frame **26** also may be polycarbonate. The use of polycarbonate can improve the strong toughness of frame **26**.

(Embodiment 2)

FIG. **9** is an external view illustrating an electronic device according to Embodiment 2. In this embodiment, audio mini stereo **44** will be described as an example of the electronic device.

Audio mini stereo **44** includes amplifier **42**, operation section **43**, enclosure **41**, and loudspeakers **30** shown in Embodiment 1. Loudspeaker **30** used for mini stereo **44** in this embodiment may use loudspeaker resin molding component **11** of any example in Embodiment 1.

Loudspeaker **30**, operation section **43**, and amplifier **42** are mounted in enclosure **41**. Operation section **43** such as a player outputs a signal to amplifier **42**. Amplifier **42** amplifies the inputted signal and outputs the amplified signal to loudspeakers **30**. Then, loudspeakers **30** receive power supplied from amplifier **42** of a main body to emit sound.

By this configuration, mini stereo **44** can reproduce clear sound. Furthermore, in a low tone range, favorable low-frequency sound can be reproduced. Clear-and-high-quality sound also can be reproduced in a high tone range. Furthermore, the sound pressure in a high tone range also can be obtained, thus reproducing the sound in a wide band frequency. Thus, mini stereo **44** can reproduce sound with a favorable audio quality.

Although audio mini stereo **44** is described as an application to the electronic device of loudspeaker **30**, the electronic device is not limited to this. The embodiment also can be widely applied and developed to a portable audio device, a video device (e.g., liquid crystal television, plasma display television), an information communication device (e.g., mobile phone), or an electronic device such as a computer-related device.

(Embodiment 3)

FIG. **10** is a conceptual diagram illustrating a mobile apparatus according to Embodiment 3. In this embodiment, automobile **50** will be described as an example of the mobile apparatus.

As shown in FIG. **10**, automobile **50** in this embodiment includes movable main body **51** and loudspeaker **30** shown in Embodiment 1. Loudspeaker **30** is accommodated in main body **51**. For example, loudspeaker **30** is mounted in a rear tray or a front panel and is used as a part of a car navigation system or a car audio system. Loudspeaker **30** used for automobile **50** in this embodiment may use loudspeaker resin molding component **11** in any example in Embodiment 1.

By this configuration, the superior characteristics of loudspeaker **30** as described above can be utilized. Specifically, automobile **50** including loudspeaker **30** can have an improved audio quality.

When frame **26** in Embodiment 1 as shown in FIG. **8** is used to loudspeaker **30**, in particular, loudspeaker **30** has a very light weight, thus contributing to improvement of fuel consumption of automobile **50**. Thus, carbon dioxide emission and fossil fuel reduction due to automobile **50** are suppressed.

A loudspeaker diaphragm, a loudspeaker, an electronic device, and an apparatus according to the present embodiments can be applied to an electronic device requiring accurate characteristics and sound (e.g., video acoustic device, information communication device) and an apparatus (e.g., automobile).

What is claimed is:

1. A loudspeaker resin molding component comprising:
carbonized bamboo fibers that are refined to have a microfibril status; and resin,
wherein the refined carbonized bamboo fibers have a freeness of 37 cc or less, and
the refined carbonized bamboo fibers have a truncal part and feathered fibers peeled off from a surface of the truncal part.

2. The loudspeaker resin molding component according to claim **1**,
wherein the refined carbonized bamboo fibers are included at 3 weight % or more and 30 weight % or less.

3. The loudspeaker esin molding component according to claim **1**,
further comprising natural fibers.

4. The loudspeaker resin molding component according to claim **3**,
wherein the natural fibers are non-carbonized bamboo fibers.

5. The loudspeaker resin molding component according to claim **4**,
wherein a sum of the refined carbonized bamboo fibers and the non-carbonized bamboo fibers is 3 weight % or more and 60 weight % or less.

6. The loudspeaker resin molding component according to claim **4**,
wherein the non-carbonized bamboo fibers are refined to have a microfibril status having a freeness of 37 cc or less.

7. The loudspeaker resin molding component according to claim
further comprising a bamboo powder.

8. The loudspeaker resin molding component according to claim **1**,
further comprising pulverized bamboo charcoal.

9. The loudspeaker resin molding component according to claim **1**,
further comprising compatibilizer consisting of a silane compound having a vinyl group.

10. The loudspeaker resin molding component according to claim **1**,
wherein the resin is polypropylene.

11. The loudspeaker resin molding component according to claim **1**,
wherein the resin is engineering plastic.

12. The loudspeaker resin molding component according to claim **1**,
wherein the resin is polylactic acid.

13. The loudspeaker resin molding component according to claim **1**,
comprising at least one of mica, talc, graphite, clay, calcium carbonate, and aramid fibers.

14. A loudspeaker comprising:
a magnetic circuit;
a frame connected to the magnetic circuit;
a diaphragm connected to the frame; and
a voice coil connected to the diaphragm and partially placed within a range on which magnetic flux generated from the magnetic circuit acts,
wherein at least one of the frame and the diaphragm is the loudspeaker resin molding component as defined in claim **1**.

15. A loudspeaker comprising:
a magnetic circuit;
a frame connected to the magnetic circuit;
a diaphragm connected to the frame;
a voice coil connected to the diaphragm and partially placed within a range on which magnetic flux generated from the magnetic circuit acts; and
a dust cap connected to the diaphragm,
wherein the dust cap is the loudspeaker resin molding component as defined in claim **1**.

16. An electronic device comprising:
an enclosure; and
the loudspeaker as defined in claim **15**, the loudspeaker being accommodated in the enclosure.

17. A mobile apparatus comprising:
a movable main body; and
the loudspeaker as defined in claim **15**, the loudspeaker being accommodated in the main body.

18. The loudspeaker resin molding component according to claim **1**,
wherein the refined carbonized bamboo fibers have been carbonized at a temperature of 500 ° C. or more.

19. A method for making a loudspeaker resin molding component, the method comprising steps of:
preparing carbonized bamboo fibers that are refined to have a microfibril status, have a freeness of 37 cc or less, and have a truncal part and feathered fibers peeled off from a surface of the truncal part;
mixing the refined carbonized bamboo fibers with a resin into a resin mixture; and
molding the resin mixture.

* * * * *